ANOMURAN SPECIES (CRUSTACEA, DECAPODA) AND THEIR ECOLOGICAL DISTRIBUTION AT FORTALEZA BAY SUBLITTORAL, UBATUBA, SÃO PAULO, BRAZIL

Maria Lucia Negreiros-Fransozo[1]
Adilson Fransozo[1]
Fernando Luis Medina Mantelatto[2]
Marcelo Antonio Amaro Pinheiro[3]
Sandro Santos[4]

ABSTRACT

The composition and distribution of the anomuran species which occur along the non-consolidated sublittoral of Fortaleza bay, Ubatuba, São Paulo, Brazil, were determined. Samplings were monthly carried out from November 1988 to October 1989 in 7 transects of 1 km each using a shrimp fishing boat equipped with two otter-trawls. Seven anomuran species of the families Diogenidae, Paguridae and Porcellanidae were recorded. The most abundant species were *Loxopagurus loxochelis* (Moreira, 1901), *Dardanus insignis* (Saussure, 1858) and *Isocheles sawayai* (Forest & Saint Laurent, 1967). The crabs were found in 11 genera of gastropod shells, with a predominance of *Thais* Röding, 1798 and *Olivancillaria* Orbigny, 1839. The spatial distribution of the anomurans was heterogeneous. The highest incidence of those animals occurring in the transect II is probably associated with the features of bottom sediment.

KEYWORDS. Anomura, ecological distribution, diversity, Brazilian coast.

INTRODUCTION

According to McLaughlin (1983), pagurid crabs comprise more than 800 species in 86 genera and six families being 12 species semiterrestrial and the remainder, marine. They represent a parcel of notorious importance in the intertidal and moderately deep benthic community, where they play an important role in the marine food chain.

1. Departamento de Zoologia, Instituto de Biociências e Centro de Aqüicultura da UNESP, 18618-000 Botucatu, São Paulo, Brasil.
2. Departamento de Biologia, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto, USP, 14040-901 Ribeirão Preto, São Paulo, Brasil.
3. Departamento de Biologia Aplicada, Faculdade de Ciências Agrárias e Veterinárias, UNESP, 14870-000 Jaboticabal, São Paulo, Brasil.
4. Departamento de Biologia, Centro de Ciências Naturais e Exatas, Universidade Federal de Santa Maria, 97119-800 Santa Maria, Rio Grande do Sul, Brasil.

In Brazil, few studies are available on hermit crabs: some dealing with systematics and distribution (FOREST & SAINT LAURENT, 1967; TOMMASI, 1967; NARCHI & HEBLING, 1976; HEBLING & RIEGER, 1986; HEBLING **et al.** 1994); others dealing with larval development (HEBLING & FRANSOZO, 1982; N.-FRANSOZO & HEBLING, 1983 and HEBLING & MANSUR, 1995); and still others are related to shell choice (N.-FRANSOZO **et al.**, 1991a; N.-FRANSOZO & FRANSOZO, 1992; PINHEIRO **et al.**, 1993). A wide study on macrocrustacean from benthic community was carried out in Fortaleza bay (23° 31' S and 45° 09' W), Brazil by N.-FRANSOZO **et al.** (1991b), FRANSOZO **et al.**, 1992; SANTOS **et al.** (1994); MANTELATTO **et al.** (1995) and N.-FRANSOZO & FRANSOZO (1995) , in which the brachyurans were emphasized.

The objective of this work was to determine the anomuran crab species occurring along the non-consolidated sublittoral of Fortaleza bay, Ubatuba (SP), and their ecological distribution.

MATERIAL AND METHODS

The anomurans were sampled in Fortaleza bay, Ubatuba, São Paulo using a shrimp fishing boat equipped with two otter-trawls, each one measuring 7.5 m in length and 10 mm of cod mesh. Samplings were monthly performed over a 12 months (from November 1988 to October 1989). Each sampling consisted of seven transects of 1 km each (fig. 1). Fortaleza bay has a mean depth of 9 m (4.4 to 13.3 m), and presented the following mean annual values for the hydrologic factors analyzed during the study period: temperature, 23.5°C (21 to 28.1°C); salinity, 34.4‰ (32.4 to 35.6‰), and dissolved oxygen, 5.46 mg/l (4.2 to 6.33 mg/l). The mean annual content of organic matter in the sediment was 4.07% (2.3 to 6.6%) and the granulometric composition of the sediment had, during most seasons, predominance of fine and very fine sand fractions. Mean annual rainfall for the Ubatuba region during the study period was 154.3 mm (27.4 to 282.6 mm). A detailed description of sampling and analysis of environmental factors at Fortaleza bay, in the same period was previously published by N.-FRANSOZO **et al.** (1991b).

The shells genera were identified as indicated by RIOS (1970) and the hermit crabs as indicated by FOREST & SAINT LAURENT (1967) and HEBLING & RIEGER (1986). The biological material is deposited in the scientific collection of the Departamento de Zoologia, Instituto de Biociências, UNESP, Campus de Botucatu. The percentage of association of hermit crabs with the genus of each gastropod shell was determined.

The diversity index of Shannon-Weaver was calculated according to POOLE (1974), where the null hypothesis was H_0: $H_1=H_2$, and it was tested by a t test ($P<0.05$). The similarity between the transects was analyzed by the Jaccard index as indicated by KREBS (1989), where the level of significance was set at 5%.

RESULTS

A total of 161 specimens of the infraorder Anomura were recorded. Of these, 126 belonging to the Diogenidae family: *Petrochirus diogenes* (Linné, 1758), *Dardanus insignis* (Saussure, 1858), *Loxopagurus loxochelis* (Moreira, 1901), and *Isocheles sawayai* (Forest & Saint Laurent, 1967). Nineteen specimens are representatives of the family Paguridae: *Pagurus criniticornis* (Dana, 1852) and *Pagurus leptonyx* (Forest & Saint Laurent, 1967). The Porcellanidae were represented only by *Porcellana sayana* (Leach, 1820) with 16 individuals. The absolute abundance of these species (tab. I) shows predominance of diogenids over pagurids and porcellanids. The most abundant species was *L. loxochelis*.

The anomuran species showed differential distribution in the studied area with all the seven recorded species present only in the transect II. The species of

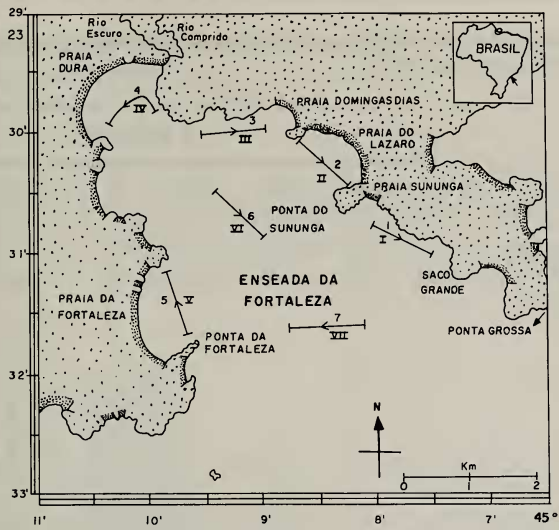

Fig. 1. Fortaleza bay in Ubatuba, São Paulo, showing the position of the sampling transects and staions.

widest spatial distribution was *L. loxochelis* (not detected only in transect VI) followed by *P. sayana*, which was absent in transect IV. All the anomuran species presented discontinuous continuous occurrence along the collecting months.

The most abundant hermit crab species was *L. loxochelis* followed by *D. insignis* and *I. sawayai.* The abundance of the anomuran species was higher in the transects with higher organic matter content (%) (fig. 2).

Eleven gastropod genera shells were found to be inhabited by the hermit crabs (tab. III). The predominant genera were *Thais* Röding, 1798 (32.14 %) and *Olivancillaria* Orbigny, 1839 (27.14 %).

The similarity index (fig. 2) reveals that transects II and V may be grouped.

The diversity index (tab. III) for each transect evidenced slightly differences in relation to hermit crabs. Transects II and V presented the highest diversity index of Shannon-Weaver, where there was no significant difference at the 5% level.

DISCUSSION

The seven sampled areas in the Fortaleza bay were reasonably homogeneous in terms of temperature, salinity and dissolved oxygen (N.-Fransozo **et al.**, 1991b). The environmental factors of widest variation, producing ecologically contrasting areas, were depth, granulometric composition, and organic matter content in the sediment. Among them, the sediment features are the most related to the benthic organisms distribution (Fransozo **et al.**, 1992).

The heterogeneous distribution of anomurans in the Fortaleza bay with respect to the sampling transects is probably associated with the contrasting levels of organic matter and granulometric composition of the sediment, reflecting specific habitats. The action of organic matter is particularly evident and the abundance of anomurans was negatively correlated with this parameter. This fact

Table I. List of the Anomuran species and number of individuals sampled per transect at Fortaleza bay, SP, from November 1988 to October 1989.

FAMILIES	TRANSECTS							
Species	I	II	III	IV	V	VI	VI	Total
DIOGENIDAE								
Loxopagurus loxochelis	22	28	8	4	14	-	2	78
Isocheles sawayai	-	1	1	19	-	-	-	21
Petrochirus diogenes	-	1	-	-	2	2	-	5
Dardanus insignis	3	8	-	2	9	-	-	22
PAGURIDAE								
Pagurus criniticornis	-	13	-	-	-	-	-	13
Pagurus leptonyx	-	3	-	-	2	1	-	6
PORCELLANIDAE								
Porcellana sayana	1	1	1	-	10	1	2	16
Total of species	3	7	3	3	5	3	2	7
Total of individuals	26	55	10	25	37	4	4	161

Table II. Relationship of the hermit crab species with the genera of gastropod shells sampled in Fortaleza Bay, SP, from November 1988 to October 1989. (1 = *Loxopagurus loxochelis*; 2 = *Isocheles sawayai*; 3 = *Petrochirus diogenes*; 4 = *Dardanus insignis*; 5 = *Pagurus criniticornis*; 6 = *Pagurus leptonyx)*. The absolute values recorded are given in brackets; 5 of the 145 specimens recorded had no shell.

Hermit crabs Gastropods	1	2	3	4	5	6	Total
Fusinus Rafinesque, 1815	-	-	-	-	15.38 (2)	-	1.43 (2)
Olivancillaria Orbigny, 1839	42.46 (31)	23.81 (5)	-	4.55 (1)	7.69 (1)	-	27.14 (38)
Thais Röding, 1798	31.51 (23)	66.67 (14)	-	9.09 (2)	38.45 (5)	16.67 (1)	32.14 (45)
Buccinanops Orbigny, 1841	19.18 (14)	4.76 (1)	-	4.55 (1)	7.69 (1)	66.66 (4)	15.0 (21)
Chiroreus Montfort, 1810	1.37 (1)	-	-	4.55 (1)	23.09 (3)	16.67 (1)	4.29 (6)
Hastula H.&A. Adams, 1853	1.37 (1)	-	-	-	-	-	0,71 (1)
Cerithium Bruguière, 1789	-	-	-	-	7.69 (1)	-	0.71 (1)
Polinices Montfort, 1810	1.37 (1)	-	-	-	-	-	0.71 (1)
Cymatium Röding, 1798	2.74 (2)	4.76 (1)	-	45.44 (10)	-	-	9.29 (13)
Tonna Brunnich, 1772	-	-	40.0 (2)	27.27 (6)	-	-	5.72 (8)
Strombus Linnaeus, 1758	-	-	60.0 (3)	4.55 (1)	-	-	2.86 (4)
Total	73	21	5	22	13	6	140

was observed for *Clibanarius vittatus* (Bosc, 1802), which inhabits areas of muddy sand that accumulate more detrital material, which appears to be a major food source for this species (Caine, 1980).

A great abundance of *Isocheles sawayai* was observed in transect IV, which is characterized by smaller amounts of organic matter and by lower salinity and depth. Furthermore, the subarea corresponding to this transect presents a predominance of very fine sand (7.58%), a fact that favours greater compacting of the bottom, allowing for animal to stay buried and not to be dragged away, especially in the surf zone. The presence of the species in this subarea may be because this

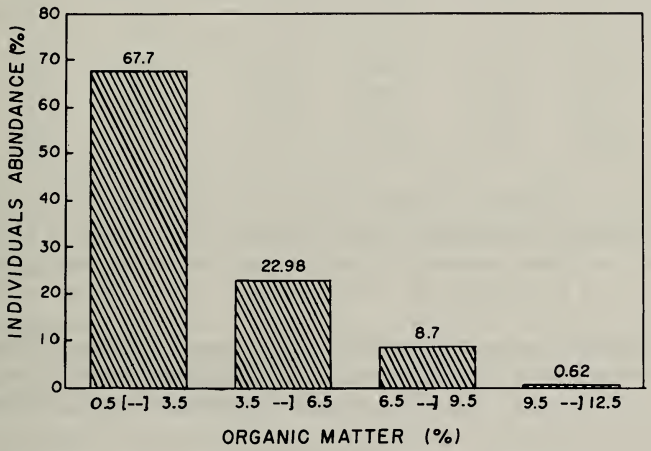

Fig. 2. Relative frequency of hermit crabs as a function of class of organic matter content.

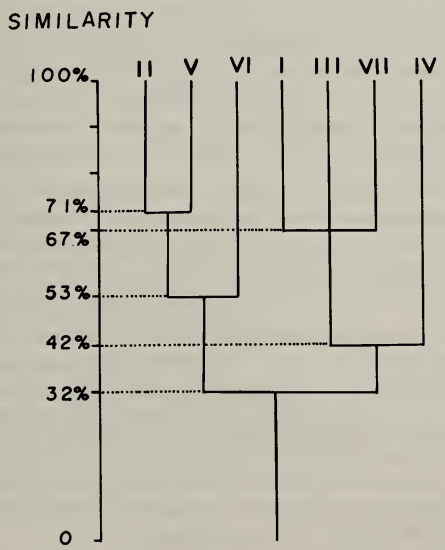

Fig. 3. Dendrogram of similarity between transects obtained by applying the Jaccard index.

hermit crab is a suspension feeder one, which prefers sites with larger amounts of particles in suspension. This species tolerates lower salinity as it is often found near sites influenced by freshwater.

Ovigerous females were detected only in *Loxopagurus loxochelis* (5 specimens),*Petrochirus diogenes* (1 specimen) and *Dardanus insignis* (1 specimen). The

Table III. Diversity index calculated for each transect (N = number of individuals; H and Hmax = Shannon-Weaver index as bits/individual; E = equitability; V = variance).

INDEX	I	II	III	IV	V	VI	VII
N	26	55	10	25	37	4	4
H	0.744	1.936	0.639	1.015	1.992	1.5	1
Hmax	1.585	2.807	1.099	1.585	2.322	1.585	1
E	0.469	0.690	0.582	0.641	0.858	0.946	1
V	0.849	0.608	0.528	0.530	094	0.981	0.23

low incidence of ovigerous females suggests a spawning behavior involving differencial habitat occupation by those females. N.-FRANSOZO & HEBLING (1983) reported that *Isocheles sawayai* is found in the surf zone during spawning and incubation, a fact explaining the total absence of this species in the sampling transects.

The occupation of gastropod shells of the genera *Thais* and *Olivancillaria* is propably correlated with a greater abundance of these specimens in the area. This occurrence was probably due to the action of local currents and tides. The lower plasticity of shell types may exert pressure on the structure of species populations in the region, as previously observed for other hermit crabs, altering growth rates (WILBER, 1990), aggressiveness (HAZLETT, 1967) and fecundity (BERTNESS, 1981).

According to PIRES (1989) who studied the structure and dynamics of the benthic megafauna at several sites along the continental shelf of the northern region of the State of São Paulo, mollusks represented the third most numerous group in the internal domain, especially in spring, and gastropods were always dominant among them, representing 60 to 73% of the Mollusca fauna sampled. Other areas along the northern littoral of São Paulo State also presented greater abundance of gastropods compared the other groups of the marine malacofauna. This aspect has been well defined in a study on the São Sebastião Canal conducted by MIGOTTO **et al.** (1993). These records may support the relatively successful presence of hermit crabs in the region. According to RITTSCHOFF (1980), hermit crabs can obtain new shells by simply changing them, by finding empty shells or by looking for sites were gastropods are preyed upon by other animals. The first two events seem to occur in Fortaleza bay, but no reports of them exist in the literature. FRANSOZO **et al.** (1992) recorded a great abundance of brachyurans in Fortaleza bay which are known to prey on gastropods (WEAR & HADDON, 1987; CHOY, 1986; HAEFNER, 1990). For instance, a study made by MANTELATTO & PETRACCO (in press) on *Hepatus pudibundus* (HERBST, 1785) diet revealed that Gastropoda were the third item in the feeding preference of these animals.

Analysis of present data suggests that the occurrence and distribution of

anomurans, and hermit crabs in particular, depends not only on favorable environmental factors but also on biogenic factors such as shell availability. These results confirm those obtained also for brachyurans (FRANSOZO **et al.**, 1992), indicating that enviromental factors, when acting together, are decisive in the ecological distribution of the benthic organisms.

Application of the similarity index revealed that transects II and V may be grouped because they share a number of species. This fact supports the similarity of these subareas observed byN.-FRANSOZO **et al.** (1991b) at the enviromental level.

Recently, HEBLING **et al.** (1994) carried out a similar study in Anchieta Island region, São Paulo State, where 12 anomuran species were recorded, for a total of 323 animals. This fact demonstrates a greater welth and abundance of anomurans for an area close to Fortaleza bay. Nevertheless, the total diversity index for Fortaleza bay (H = 2.2388 bits/ind.; Equitability = 0.7975; Variance= 0.0687) and for Anchieta Island (H= 2.7481 bits/ind.; Equitability = 0.7666; Variance= 0.0309) does not differs significantly ($p>0.05$; $t = 1.61$), which means a similar anomuran composition in neighboring areas monitored at different times. As observed near Anchieta Island and in Fortaleza bay, the geographic position of the transects in relation to the land characterizes different environmental conditions, implying that different influences exist on the distribution of benthic species.

Acknowledgments. This research was supported by Conselho Nacional de Desenvolvimento Científico and Tecnológico (CNPq) and by Fundação de Amparo à Pesquisa da UNESP (FUNDUNESP). To Dr. Nilton José Hebling for confirming the identification of the hermit crabs, and Msc. Augusto A.V. Flores and Eduardo A. Geraque for helping in the laboratory work.

REFERENCES

BERTNESS, M. D. 1981.The influence of shell-type on hermit crab growth rate and clutch size (Decapoda, Anomura). **Crustaceana**, Leiden, **40**(2):197-205.

CAINE, E. A. 1980. Adaptations of a species of hermit crab (Decapoda, Paguridea) inhabiting sessile worm tubes. **Crustaceana**, Leiden, **38**(3):306-310.

CHOY, S. C. 1986. Reproductive biology of *Liocarcinus puber* and *L. holsatus* (Decapoda, Brachyura, Portunidae) from the Gower Peninsula, south Wales. **Mar. Ecol. Prog. Ser.**, Amelinghausen, **9**(3):227-241.

FOREST, J. & SAINT LAURENT, M. de 1967. Campagne de la "Calypso" au large des côtes Atlantiques de l'Amérique du sud (1961-1962). 6. Crustacés Décapodes: Pagurides. **Annls. Inst. océanogr. Monaco**, Mônaco, **45**(2):47-169.

FRANSOZO, A.; N.-FRANSOZO, M. L. **et al.** 1992. Composição e distribuição dos Brachyura (Crustacea, Decapoda) do sublitoral não-consolidado na Enseada da Fortaleza, Ubatuba (SP). **Revta bras. Biol.**, Rio de Janeiro, **52**(4):667-675.

HAEFNER Jr., P. A. 1990. Natural diet of *Callinectes ornatus* (Brachyura, Portunidae) in Bermuda. **J. Crust. Biol.**, San Antonio, **10**(2):236-246.

HAZLETT, B. A. 1967. Interspecific shel fighting between *Pagurus bernhardus* and *Pagurus cuanensis* (Decapoda, Paguridea). **Sarsia**, Oslo, **29**:215-220.

HEBLING, N. J. & FRANSOZO, A. 1982. Desenvolvimento pós-embrionário de *Paguristes erythrops* Holthuis, 1959 (Decapoda, Diogenidae), em laboratório. **Revta bras. Biol.**, Rio de Janeiro, **42**(1): 117-128.

HEBLING, N. J. & MANSUR, C. B. 1995. Desenvolvimento larval de *Dardanus insignis* (Saussure, 1858) (Crustacea, Decapoda, Diogenidae), em laboratório. **Revta bras. Zool.**, São Paulo, **12**(3):471-491.

HEBLING, N. J. ; MANTELATTO, F. L. M. **et al.** 1994. Levantamento e distribuição de braquiúros

e anomuros (Crustacea, Decapoda) dos sedimentos sublitorais da região da Ilha Anchieta, Ubatuba (SP). **Bolm. Inst. Pesca**, São Paulo, **21**:1-9.

HEBLING, N. J. & RIEGER, P. J. 1986. Os ermitões (Crustacea, Decapoda: Paguridae e Diogenidae) do litoral do RS, Brasil. **Atlântica**, Rio Grande, **8**: 63-77.

KREBS, C. J. 1989. **Ecological Methodology**. New York, Harper & Row, 654p.

MANTELATTO, F. L. M.; FRANSOZO, A. & N.- FRANSOZO, M. L. 1995. Distribuição do caranguejo *Hepatus pudibundus* (Herbst, 1785) (Crustacea, Decapoda) na Enseada da Fortaleza, Ubatuba (SP), Brasil. **Bolm Inst. Oceanogr.**, São Paulo, **43**(1):51-61.

MANTELATTO, F. L. M. & PETRACCO, M. (in press) Natural diet of the crab *Hepatus pudibundus* (Crustacea, Brachyura, Calappidae) in Fortaleza bay, Ubatuba (SP), Brazil. **J. Crust. Biol.**, San Antonio.

McLAUGHLIN, P. 1983. Hermit crabs - are they really polyphyletic? **J. Crust. Biol.**, San Antonio, **3**(4):608-621.

MIGOTTO, A. E.; TIAGO, C. G. & MAGALHÃES, A. R. M. 1993. Malacofauna marinha da região costeira do Canal de São Sebastião, SP, Brasil: Gastropoda, Bivalvia, Polyplacophora e Scaphopoda. **Bolm Inst. Pesca**, São Paulo, **41** (1/2):13-27.

NARCHI, W. & HEBLING, N. J. 1976. *Calcinus tibicen* (Herbst, 1791) in Brazilian littoral (Decapoda, Paguridea). **Papéis Avuls Zool.**, São Paulo, **26**(6):67-71.

N.-FRANSOZO, M. L. & FRANSOZO, A. 1992. Estrutura populacional e relação com a concha de *Paguristes tortugae* Schmitt, 1933 (Decapoda, Diogenidae) no litoral norte do Estado de São Paulo, Brasil. **Naturalia**, Rio Claro, **17**:31-42.

__. 1995. On the distribution of *Callinectes ornatus* Ordway, 1863 and *Callinectes danae* Smith, 1869 (Brachyura, Portunidae) in Fortaleza bay, Ubatuba (SP), Brazil. **Iheringia** Sér. Zool., Porto Alegre, (79):13-25.

N.-FRANSOZO, M. L.; FRANSOZO, A. & HEBLING, N. J. 1991. Estrutura populacional e determinação do tamanho da concha ocupada por 4 espécies de ermitões (Crustacea, Decapoda, Anomura) do litoral de São Paulo. **Biotemas**, Florianópolis, **4**(2):135-148.

N.-FRANSOZO, M. L.; FRANSOZO, A.; PINHEIRO, M. A. A. **et al.** 1991. Caracterização física e química da Enseada da Fortaleza, Ubatuba (SP). **Revta. bras. Geoc.**, São Paulo, **21**(2):114-120.

N.-FRANSOZO, M. L. & HEBLING, N. J. 1983. Desenvolvimento pós-embrionário de *Isocheles sawayai*, Forest & Saint Laurent, 1967 (Decapoda, Diogenidae) em laboratório. **Papéis Avuls Zool.**, São Paulo, **35**(4): 41-53.

PINHEIRO, M. A. A; FRANSOZO, A. & N.-FRANSOZO, M. L. 1993. Seleção e relação com a concha em *Isocheles sawayai* Forest & Saint Laurent, 1967 (Crustacea, Anomura, Diogenidae). **Arq. Biol. Tecnol.**, Curitiba, **36**(4):745-752.

PIRES, A. M. S. 1989. **Estrutura e dinâmica da megafauna bêntica na plataforma continental da Região Norte do Estado de São Paulo, Brasil.** 172p. Tese de livre docência IO- USP, São Paulo, SP. [Não publicada]

POOLE, R. W. 1974. **An introduction to quantitative ecology.** N. York, McGraw-Hill, 532p.

RIOS, E. C., 1970. **Coastal Brazilian seashells.** Rio Grande, Fundação Cidade do Rio Grande, Museu Oceanográfico do Rio Grande, 255 p.

RITTSCHOFF, D. 1980. Chemical attractions of hermit crabs and other attendants to simulated gastropod predations sities. **J. Chem. Ecol.**, New York, **6**:103-118.

SANTOS, S.; N.-FRANSOZO, M. L. & FRANSOZO, A. 1994. The distribution of the swimming crab *Portunus spinimanus* Latreille, 1819 (Crustacea, Brachyura, Portunidae) in the Fortaleza bay. **Atlântica**, Rio Grande, **16**:125-141.

TOMMASI, L. R. 1967. Observações preliminares sobre a fauna bêntica de sedimentos moles da baía de Santos e regiões vizinhas. **Bolm Inst. oceanogr.**, São Paulo, **16**(1):43-55.

WEAR, R. G. & HADDON, M. 1987. Natural diet of the crab *Ovalipes catharus* (Crustacea, Portunidae) around central and northern New Zealand. **Mar. Ecol. Prog. Ser.**, Amelinghausen, **35**:39-49.

WILBER Jr., T. P. 1990. Associations between crab morphology and gastropod shell species in the hermit crab *Pagurus longicarpus*. **J. Crust. Biol.**, San Antonio, **10**(1):134-138.

Recebido em 06.12.1996; aceito em 02.07.1997.